

California Energy Commission

2005 Integrated Energy Policy Report

Water-Energy Relationship Workshop

*Sacramento, CA
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The Water/Energy Nexus

Energy Flow in the Water Cycle: A New Spaghetti Chart

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Points to Cover

1. Overview: The Water / Energy Nexus
2. Energy Intensity
3. Energy Inputs in California's Water
4. Research Questions

Overview: The Water/Energy Nexus

We get energy from water, and we use energy to supply, treat, and use water.

Overview: The Water/Energy Nexus

The delivery of water in California accounts for one of the largest electricity energy uses in the state, currently estimated at about 7-8% of the state's overall usage.

Key Concerns (Water and Energy)

- Reliability (supply)
- Cost (supply and quality)
- Quality (for various uses)
- Environmental Impacts

Similar Issues (Water and Energy)

- Historic supply-side orientation
- Infrastructure is important
- Huge end-use efficiency opportunities
- New technologies are changing our notions of optimal scale
- Market distortions
- Disconnect between pricing and cost

“New” Management Approaches

Integrated management (water, wastewater, stormwater, energy, ...)

Multiple benefits (policy and investments)

Portfolio strategies (supply, management, risk, cost)

(A Note on Water Units)

The common unit for water supply is an “acre-foot” (AF).

An acre-foot of water is the volume of water that would cover one acre with one foot. An acre-foot equals 325,851 gallons, or 43,560 cubic feet, or 1,233.65 cubic meters.

Energy Intensity

Energy intensity, or embodied energy, is the total amount of energy, calculated on a whole-system basis, required for the use of a given amount of water in a specific location.

Energy Inputs to Water Systems

There are four principle energy elements in water systems:

1. primary water extraction, conveyance, storage (in some cases), and supply delivery (imported and local)
2. treatment and distribution within service areas
3. on-site water pumping, treatment, and thermal inputs (heating and cooling)
4. wastewater collection and treatment

Pumping

Pumping water in each of these four stages is energy-intensive and constitutes a major use of California's total energy.

End-Use Energy Inputs

1. On-site treatment (e.g. water softening, additional filtration, etc.)
2. Pressurization and recirculation loops within buildings and facilities
3. thermal requirements (heating / cooling)
4. wastewater pumping

Water Use and Energy Implications

1. When is water used (diurnal and seasonal)?
2. Where is water used, and where is the energy connected to that water needed?
3. How much water is used?
4. What are the sources of that water?

Important Research Questions

1. Where and when will water systems use more energy (e.g. desalination)?
2. Where and when will water systems use less energy (e.g. efficiency improvements, reuse, shift in supply options, etc.)?
3. What information and data do we need to support good policy?

The California Context

California Conveyance Systems

California's water systems are uniquely energy-intensive, relative to national averages, due to pumping requirements for major conveyance systems which move large volumes of water long distances and over thousands of feet in elevation lift.

Major Rivers and Interbasin Conveyance Systems in California

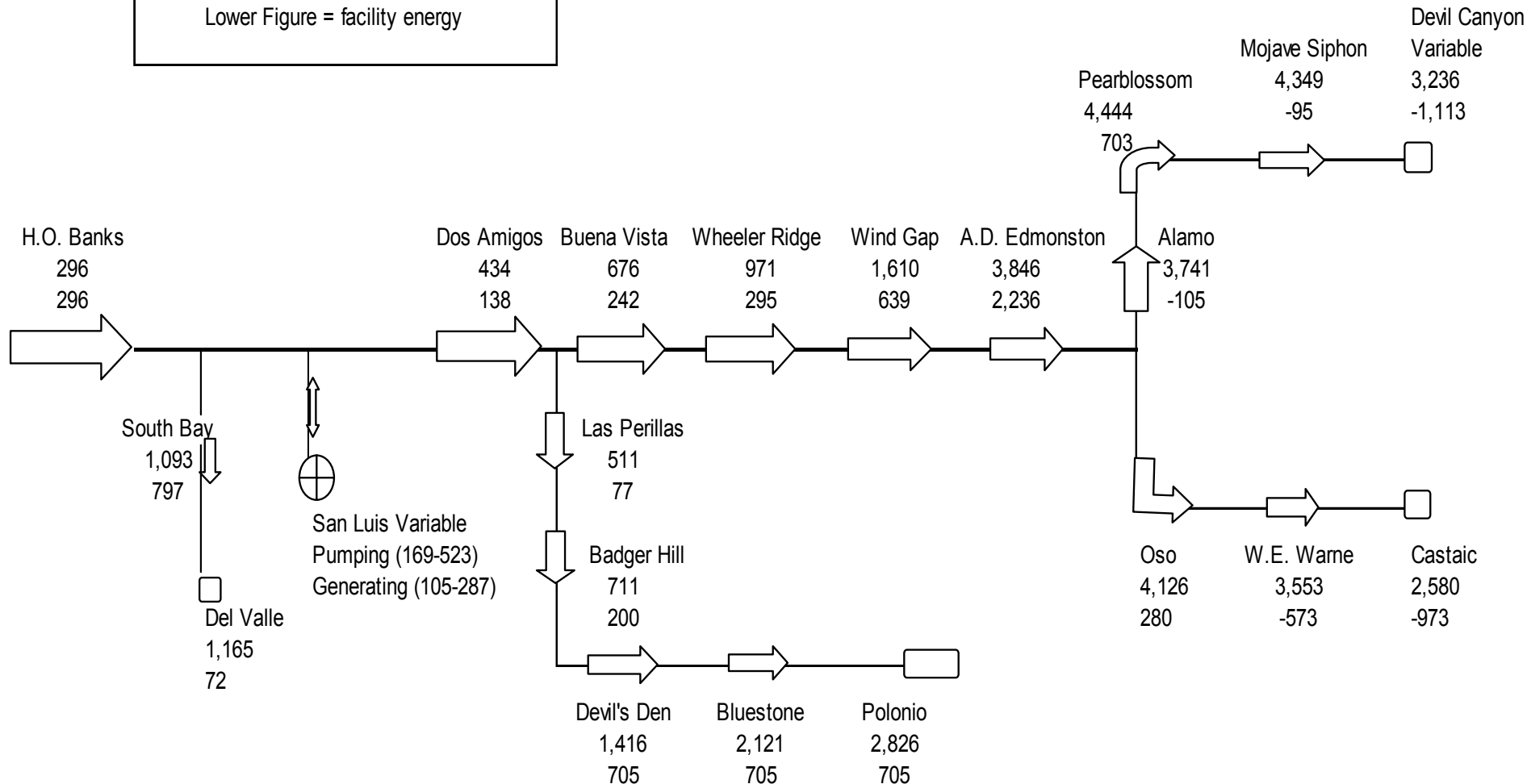


State Water Project Pumping Facilities



State Water Project Pumping Energy

All figures: kWh/AF
 Top figure = cumulative energy
 Lower Figure = facility energy



(Includes Energy Recovery and Transmission Losses)

Marginal Energy Intensity of Water Use in Southern California

Energy requirements calculated for marginal (e.g. imported supply) water use in Southern California, including all steps *except* end-use energy, is 3,519 kWh/acre-foot.

(= 0.01 kWh/gallon).

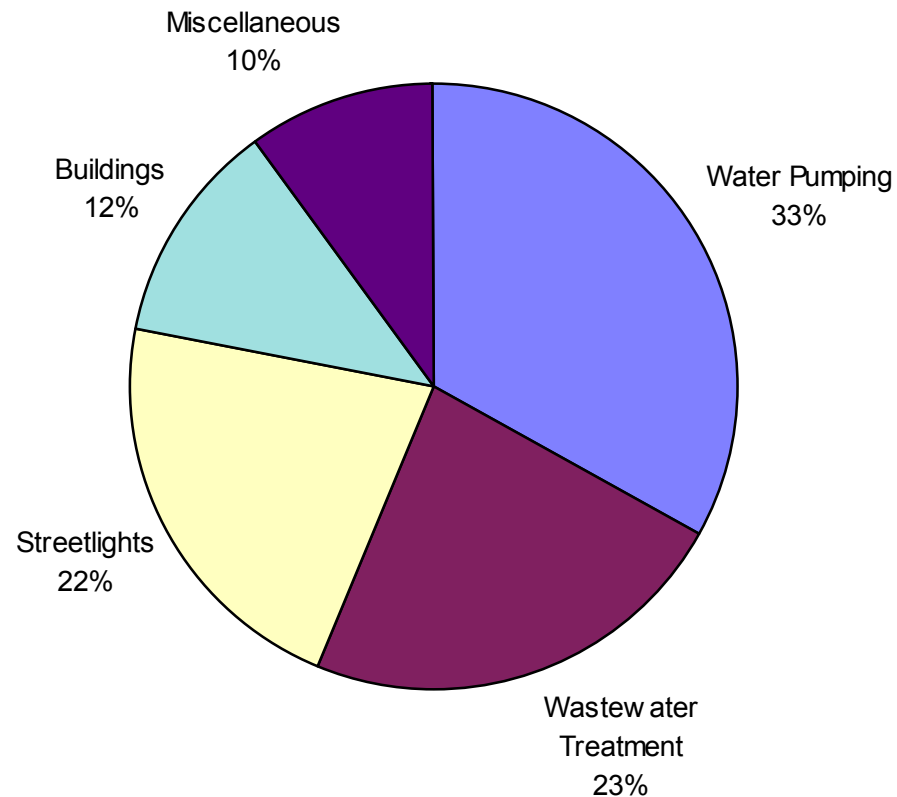
California's Major Interbasin Water Supply Projects



The Energy / Water Nexus

SAMPLE CITY ENERGY USE

(California Energy Commission, 1992, *Energy Efficiency Programs for Cities, Counties, and Schools* , P400-91-030, p.5)

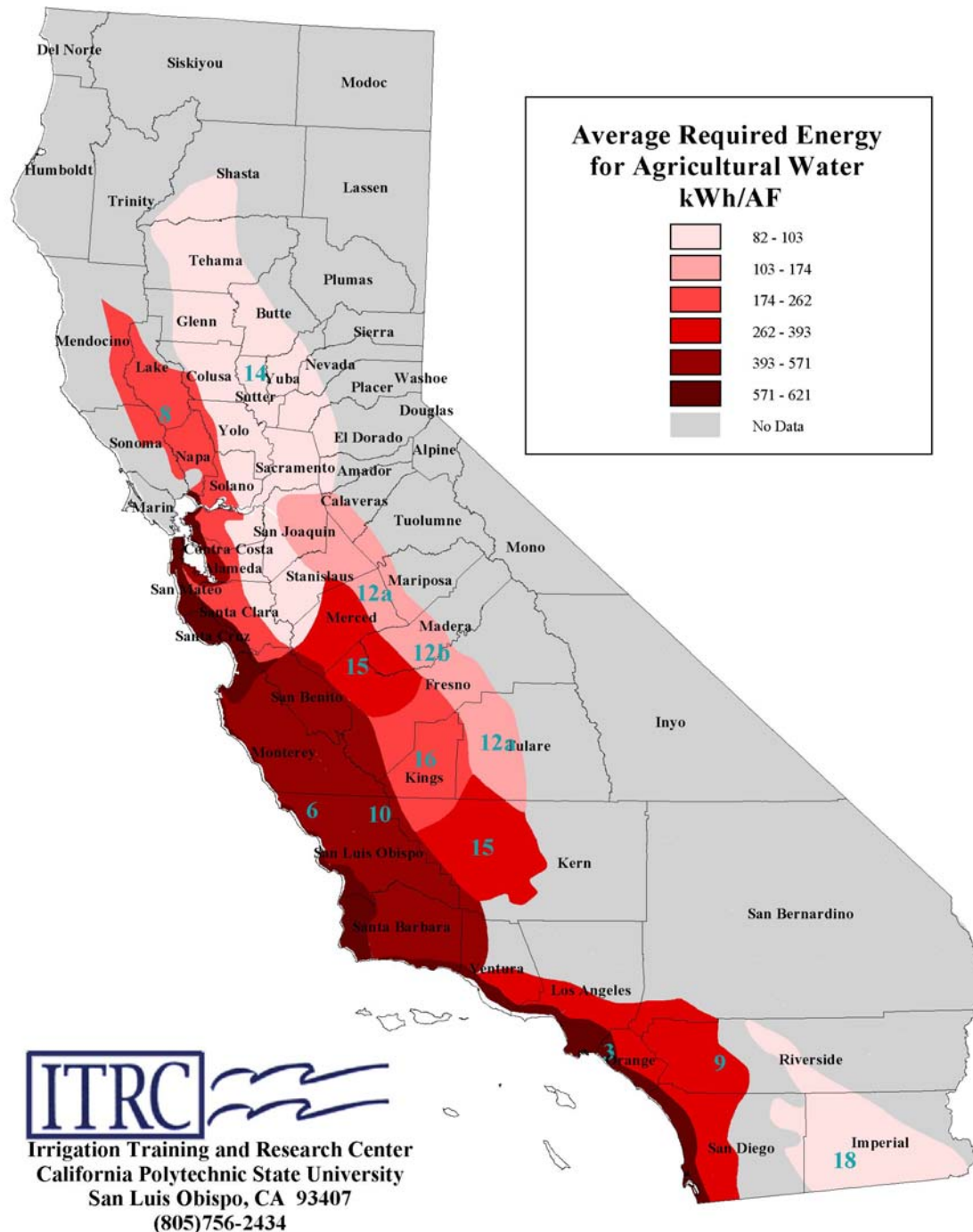


Energy Intensity for Agricultural Water Use

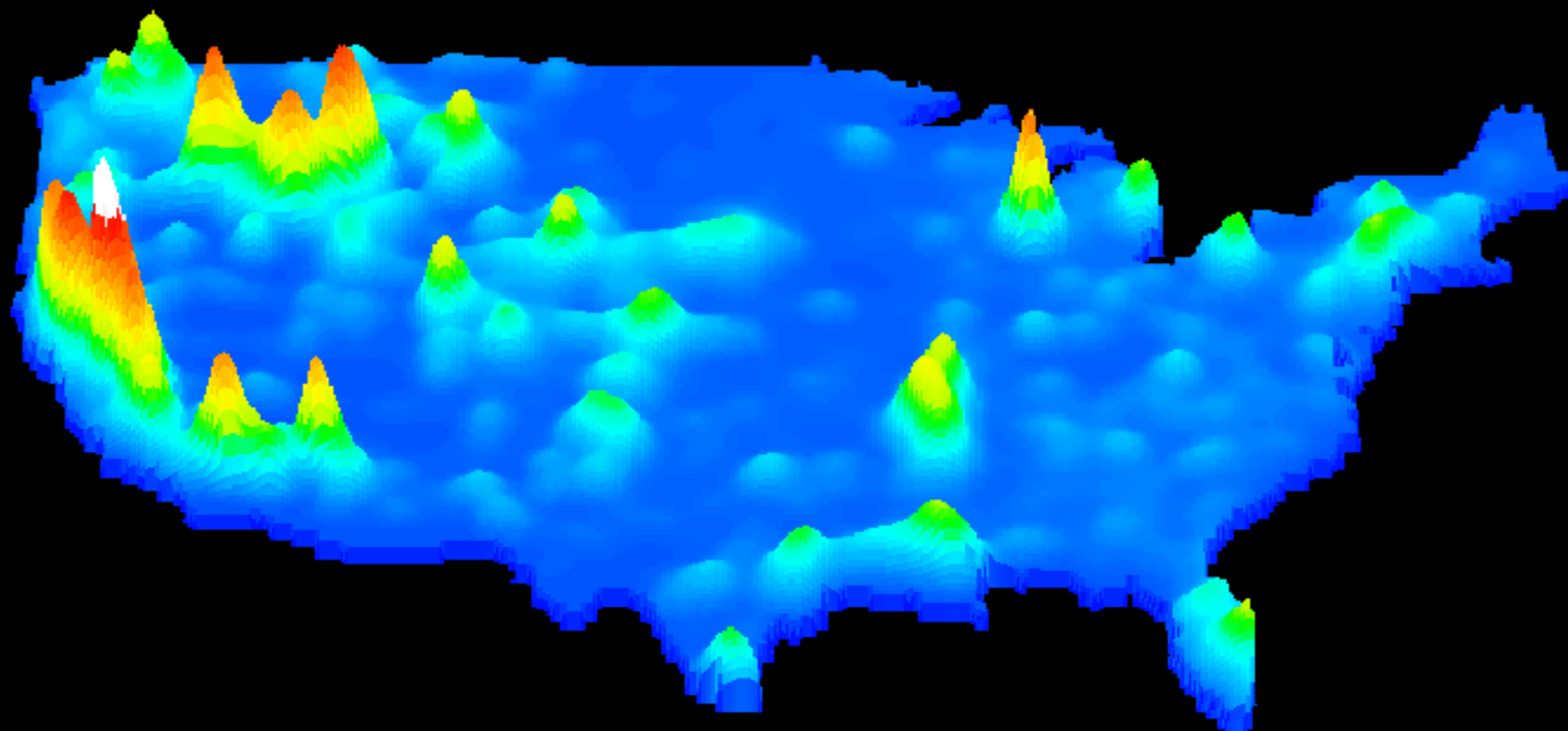
*California Agricultural Water
Electrical Energy Requirements*

Charles Burt, Dan Howes, and
Gary Wilson

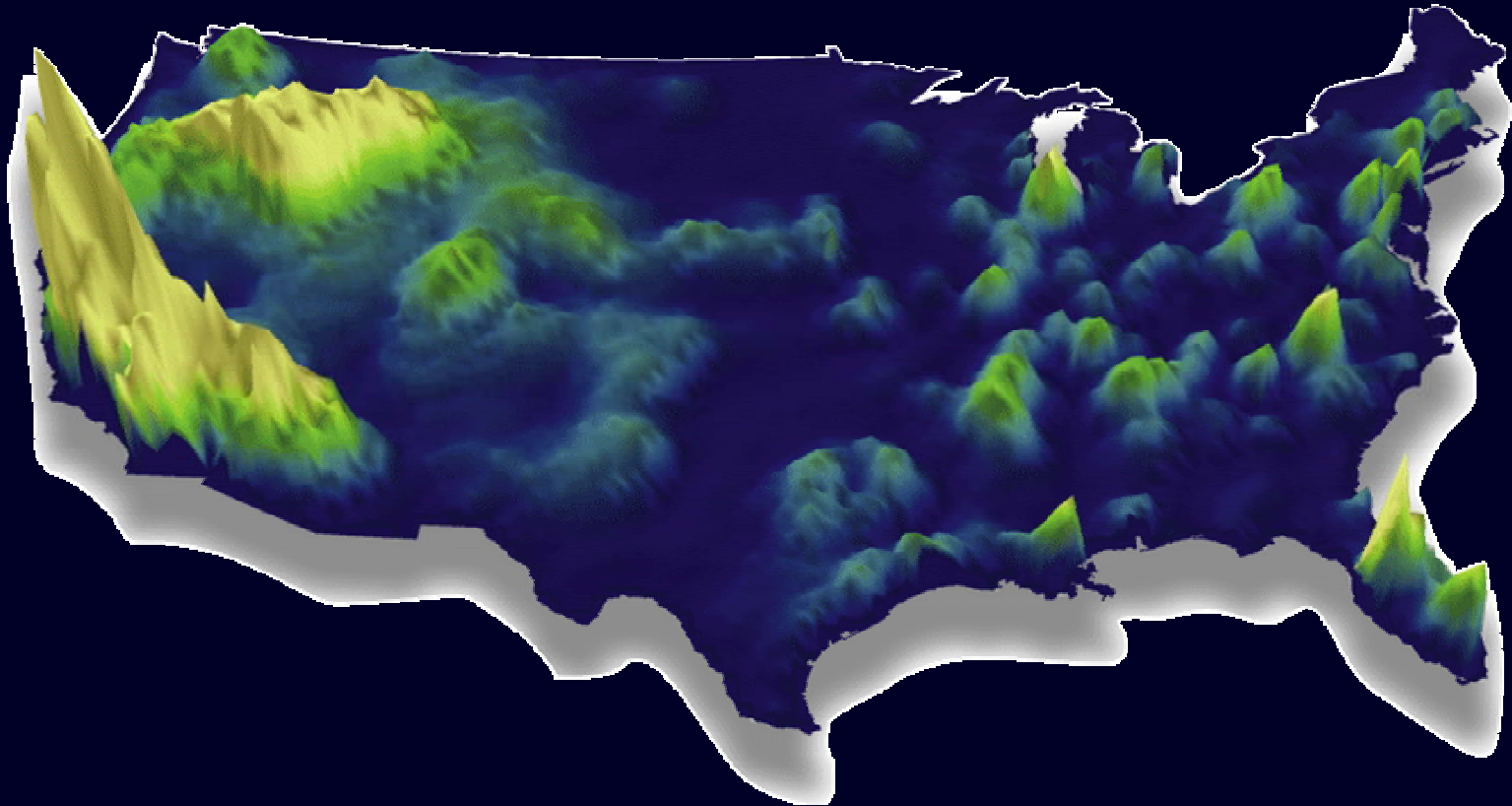
Irrigation Training and Research
Center (ITRC) California
Polytechnic State University



1990 TOTAL WATER WITHDRAWALS (excluding power)



Total Water Withdrawals, 2000



Source: **USGS Circular 1268, 15 figures, 14 tables** (released March 2004 and revised April and May 2004)

Available at: <http://water.usgs.gov/pubs/circ/2004/circ1268/index.html>

Water Supply

Every major water supply system in California is over-allocated.



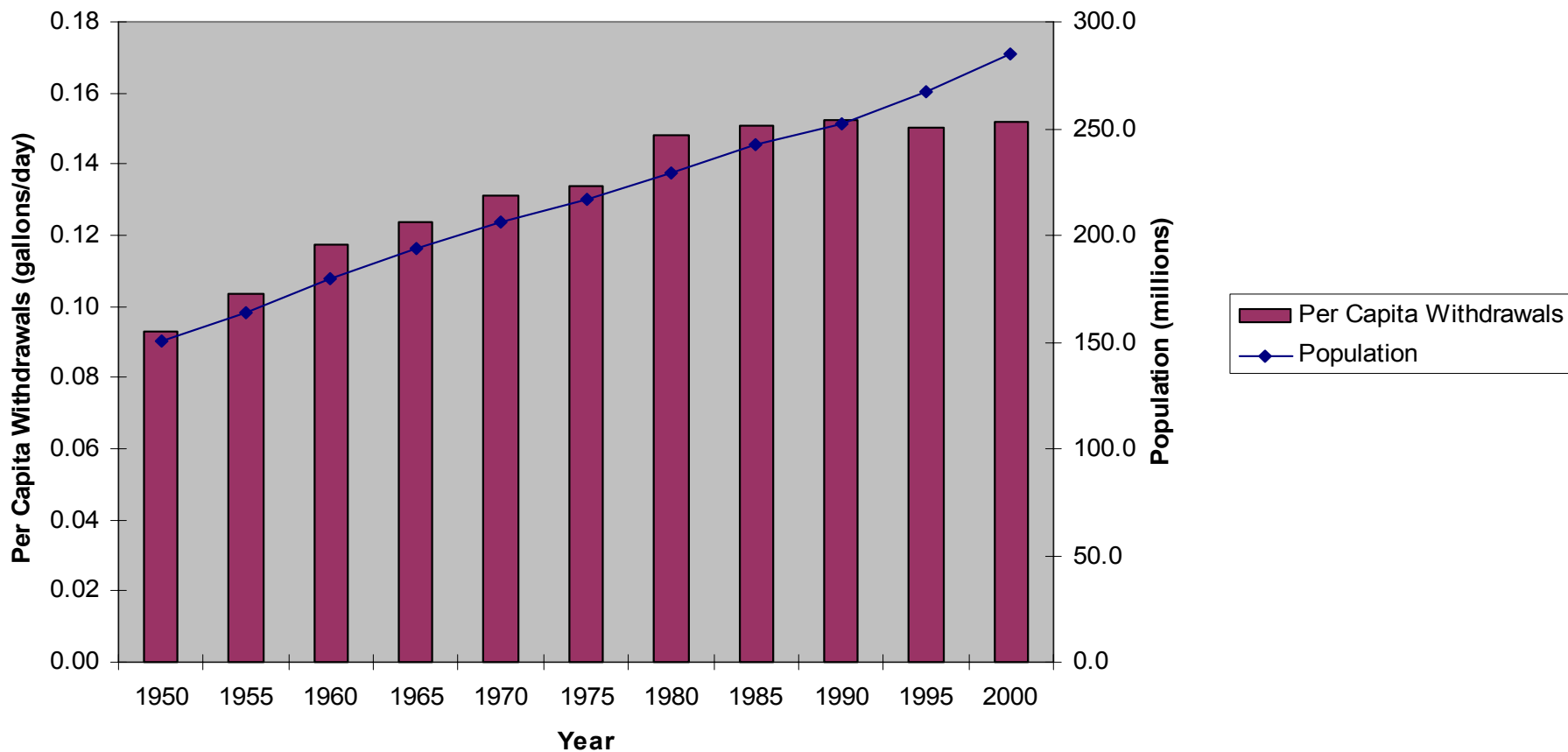
A New Paradigm

The new paradigm of this century is water supply issues will no longer be driven by droughts. We will have conflict in normal years, and that conflict will affect economies of national importance. The demands for water in many basins of the West exceed the available supply even in normal years.

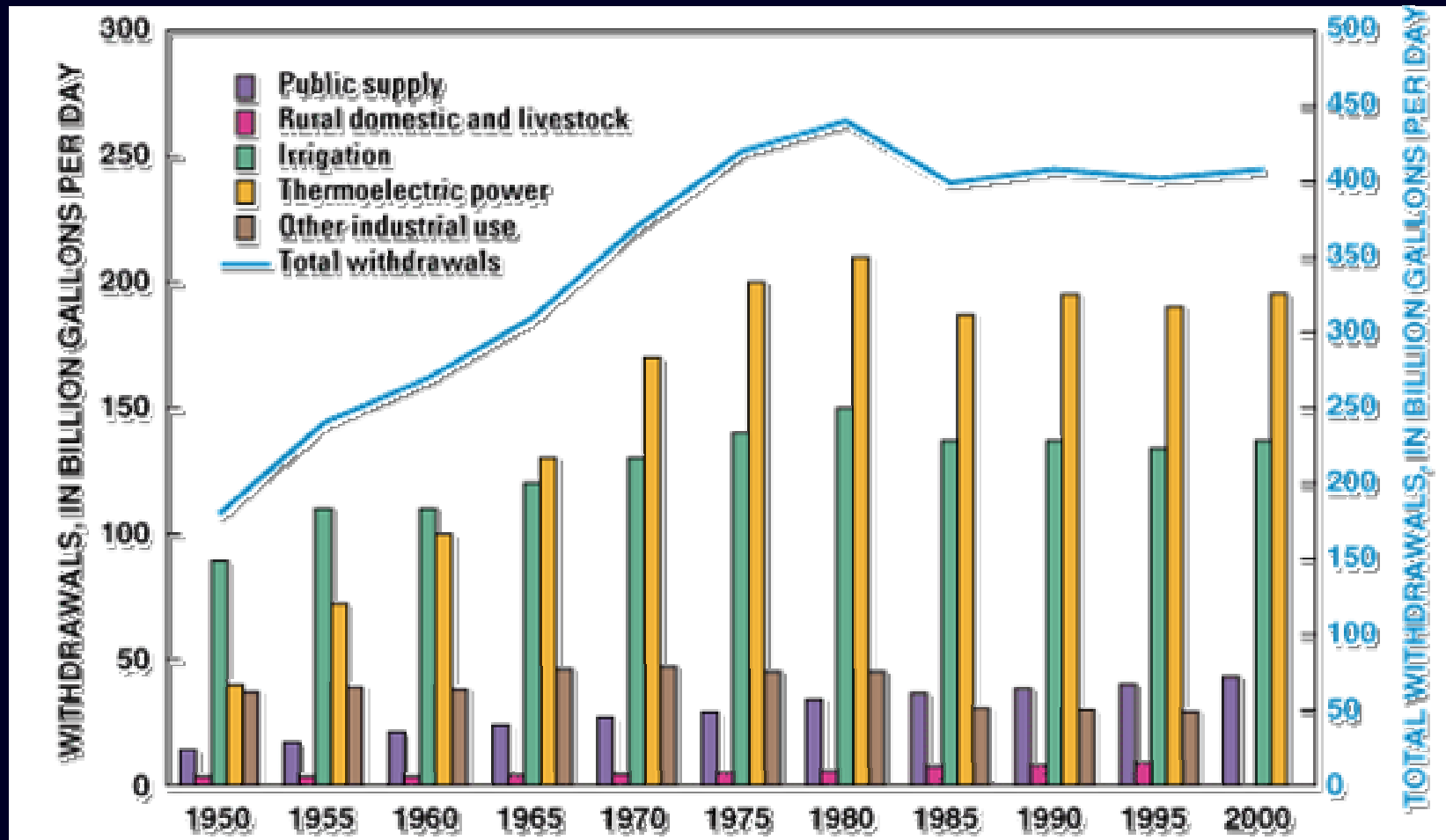
Bennett Raley, Assistant Interior Secretary for Water and Science
Las Vegas Review-Journal - 3/10/04

Public Supply: Per Capita Withdrawals and Population

Public Supply: Per Capita Water Withdrawals and Population



Trends in Total Water Withdrawals by Water Use Category 1950-2000



Water management trends are following the energy sector experience

“During the last decade, the arena of long-term water resources planning has been broadened to include conservation as a promising management alternative. Water supplies are currently undergoing the same change which took place in the energy industry during the 1970s.”

Energy Standards

The *Energy Policy Act* of 1992 established national standards set for plumbing fixtures, although many states had already adopted similar standards on their own.

The Act sets minimum water efficiency standards at the federal level for plumbing fixtures.

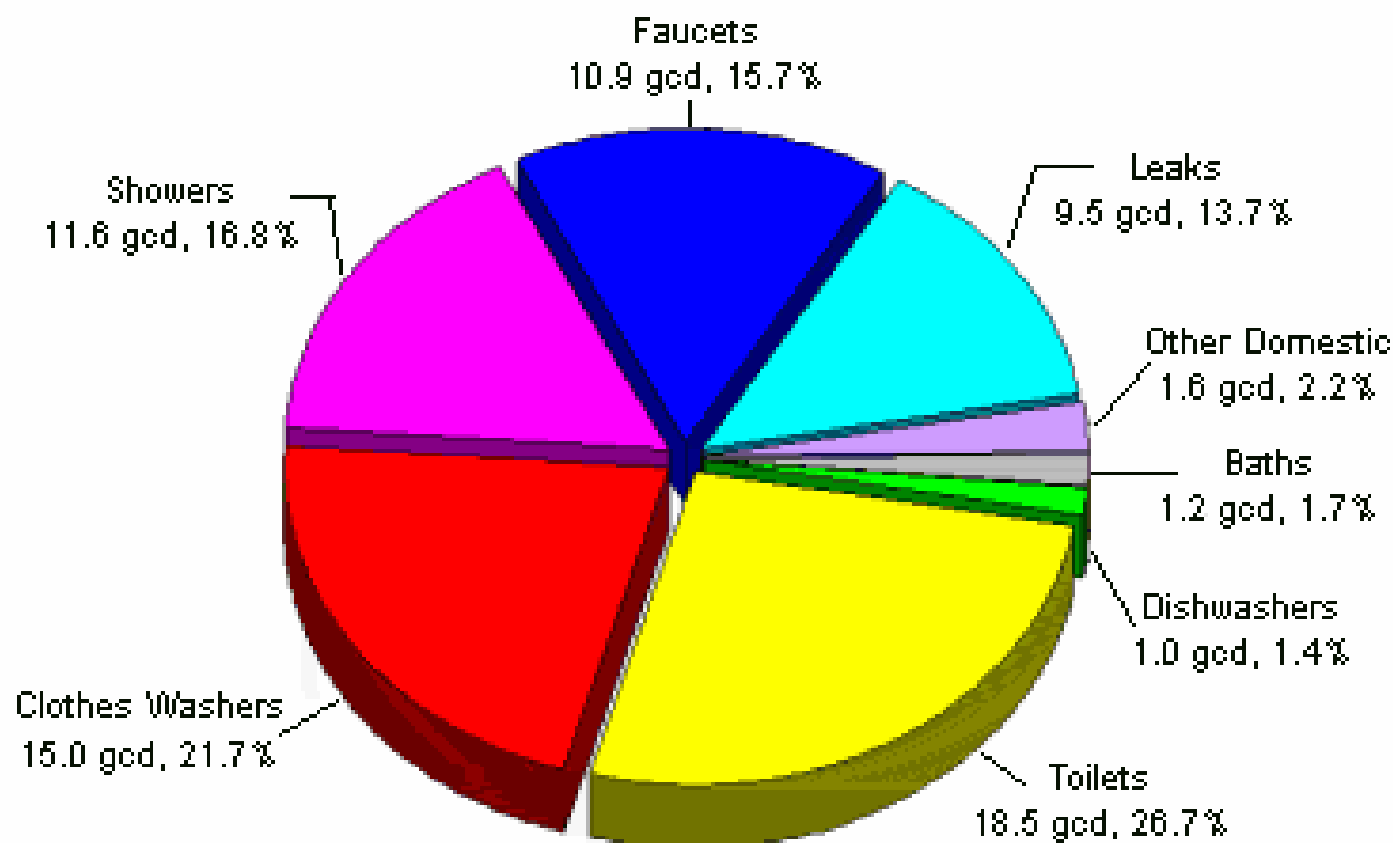
Water Efficiency Standards

Fixture	U.S. Standard*
Toilets	1.6 gallons per flush
Showerheads	2.5 gallons per minute
Faucets	2.2 gallons per minute
Urinals	1 gallon per flush

* *Standard measured at 80 psi*

Indoor Residential Water Use

Mean Per Capita Residential Indoor Water Use



Total: 69.3 gallons per capita per day (gpcd)

Presented by WaterWiser - © 1999 AWWA Research Foundation & American Water Works Association

Data from Residential End Uses of Water

Water (and Energy) Savings

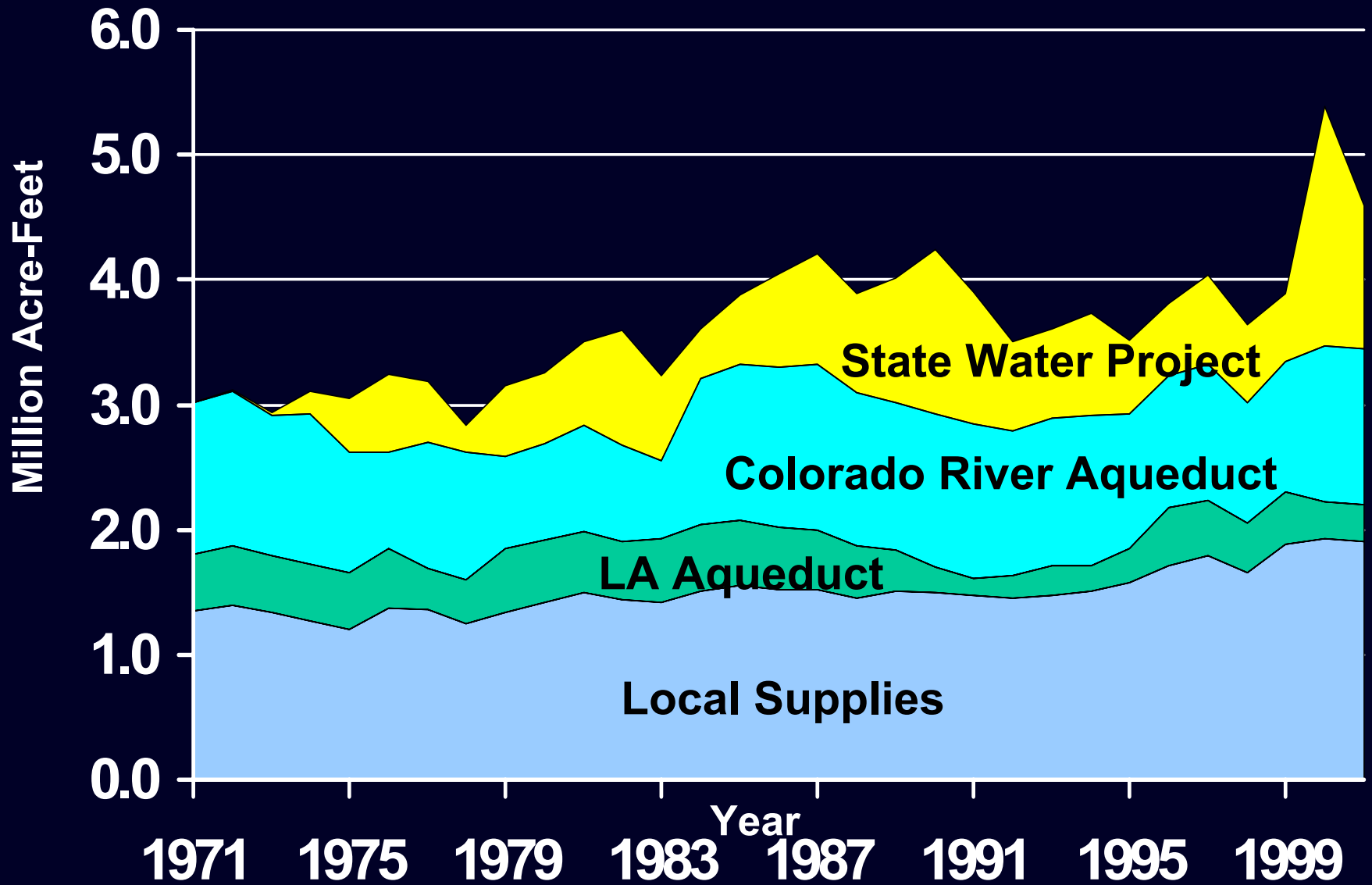
In less than a decade (by 1998) MWD and its member agencies had replaced 1 million water-wasting toilets with ultra-low flush models and distributed approximately 3 million low-flow showerheads.

MWD estimated these fixtures saved more than 44,000 acre-feet annually.

California's Major Interbasin Water Supply Projects



Sources of Water Supply in MWD's Service Area



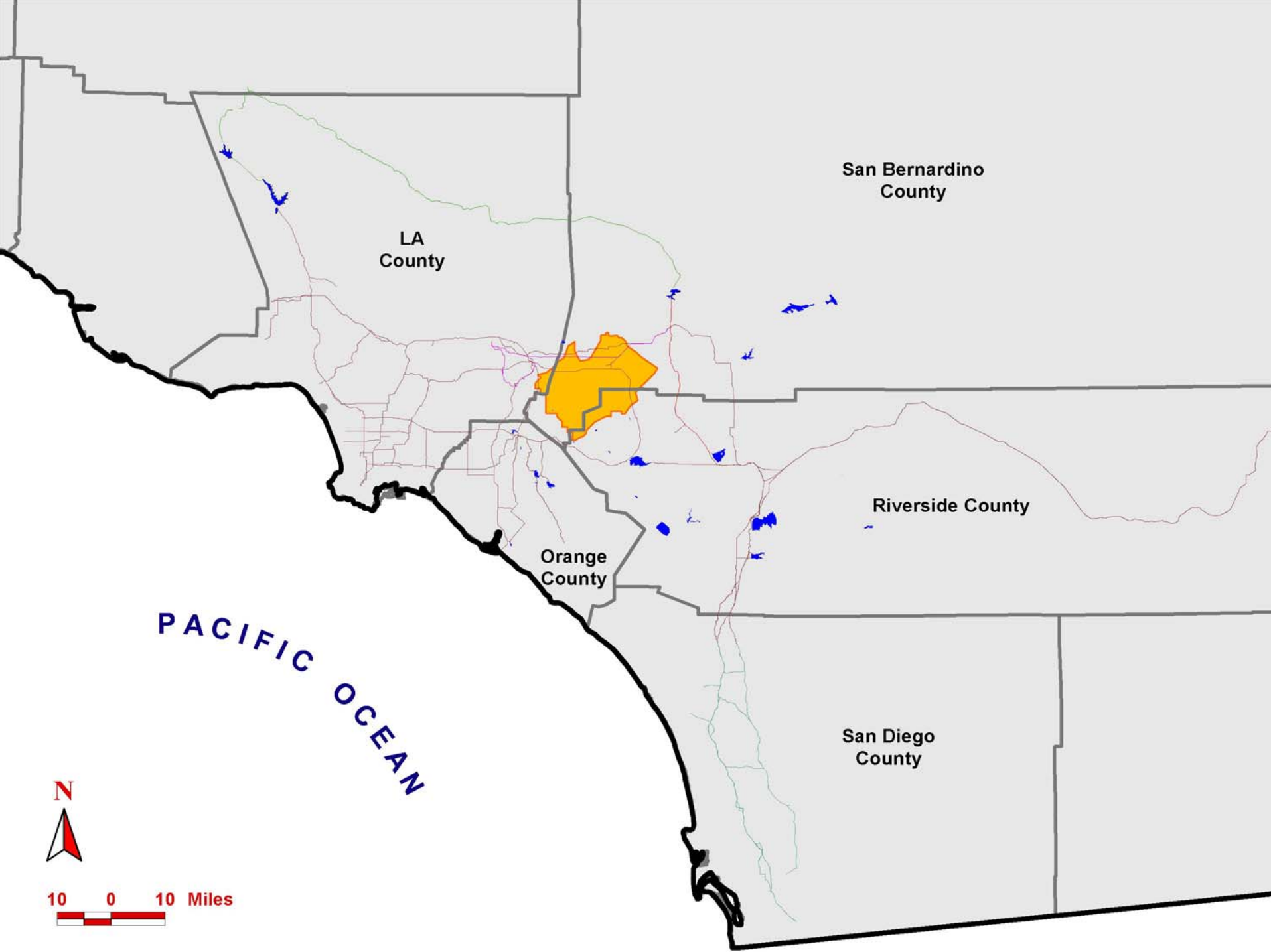
Local Water Sources in Southern California

Nearly half (46%) of the water used in the service area of the Metropolitan Water District of Southern California (Ventura to Mexico) is in fact secured from *local* sources, and the percentage of total supplies provided by local sources is growing steadily.

Metropolitan Water District of Southern California, 2000. *The Regional Urban Water Management Plan for the Metropolitan Water District of Southern California*, p.A.2-3.

Two Local Water / Energy Examples





LA
County

San Bernardino
County

Riverside County

Orange
County

San Diego
County

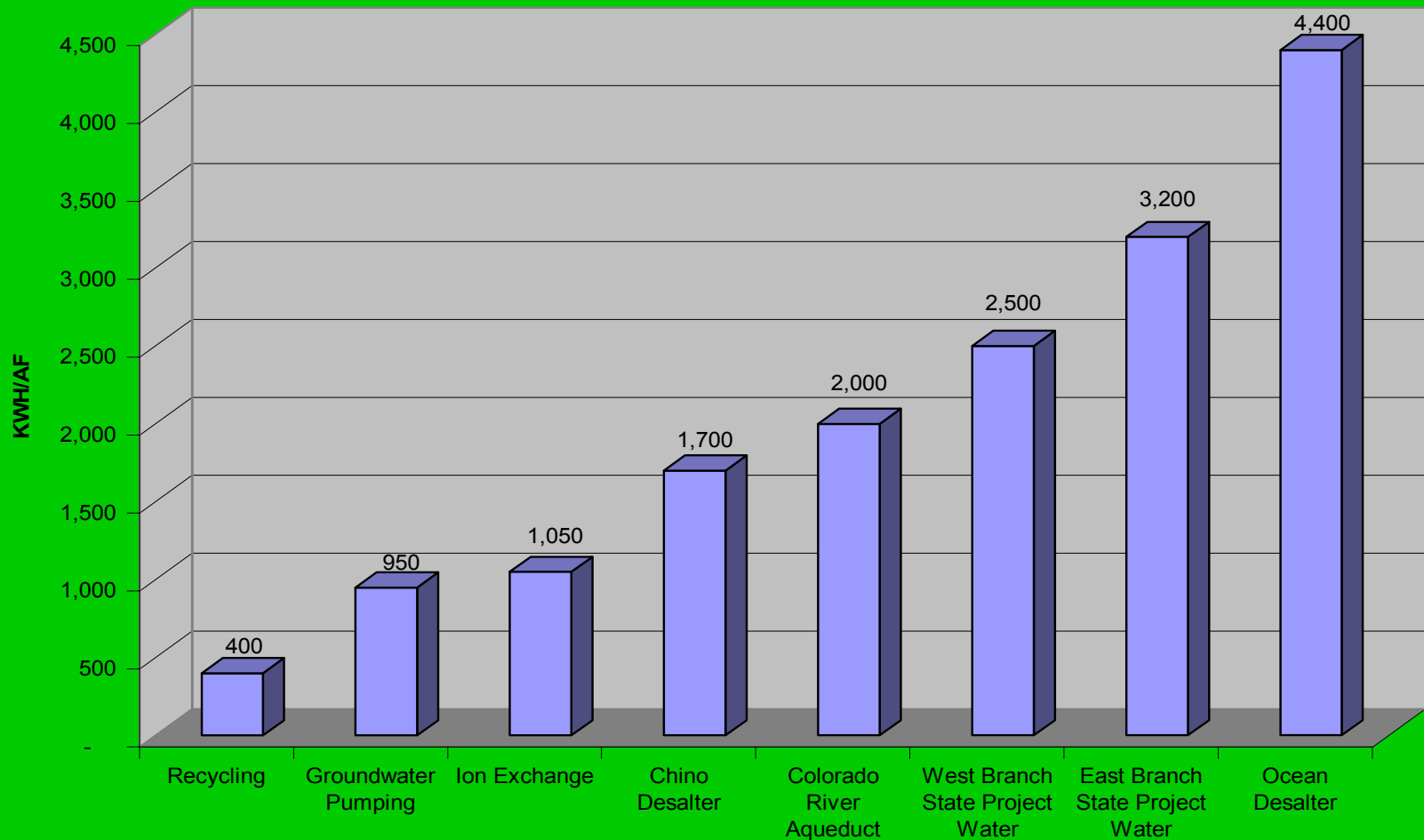
PACIFIC OCEAN



10 0 10 Miles

Energy Intensity of Water Supplies for IEUA

Energy Use by Source



Montclair Basins

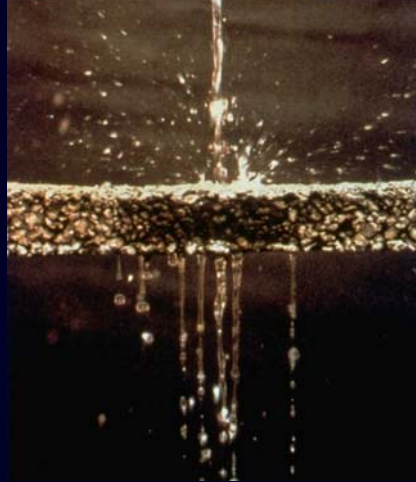


Infiltration Islands



Courtesy of Bruce Ferguson

Cool and Permeable Surfaces

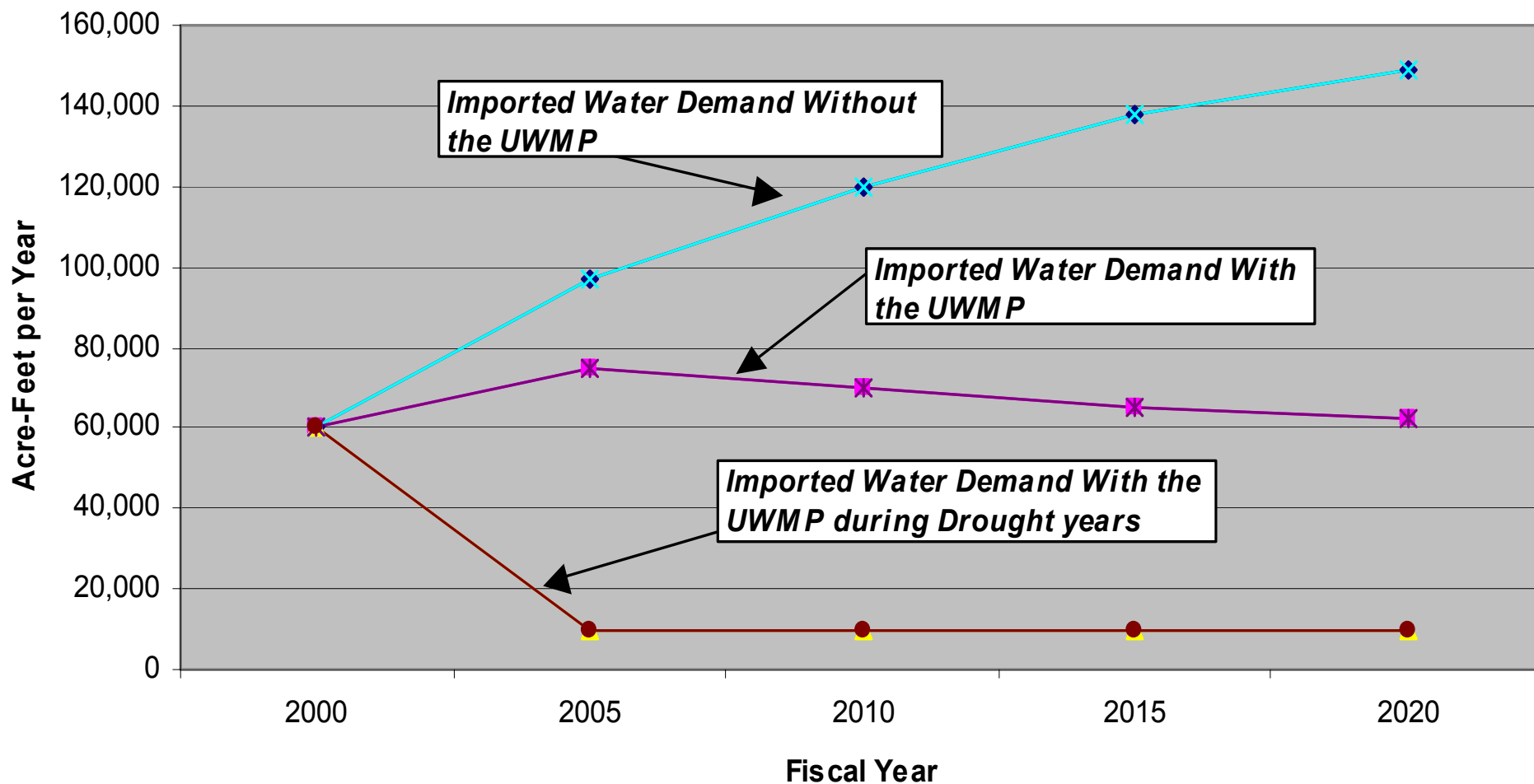


Inland Empire Utilities
Agency (Chino Basin)

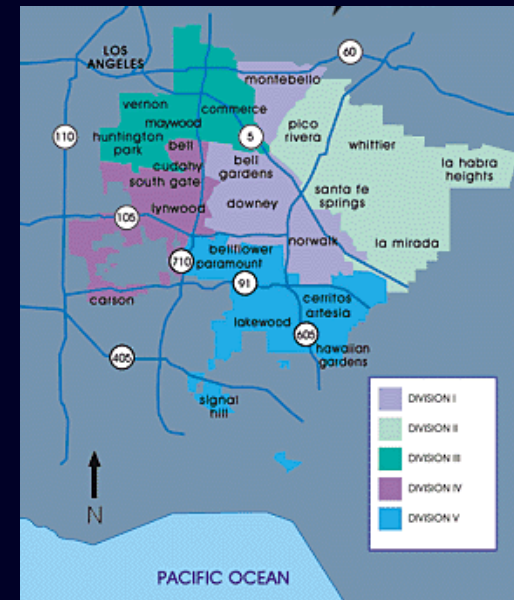
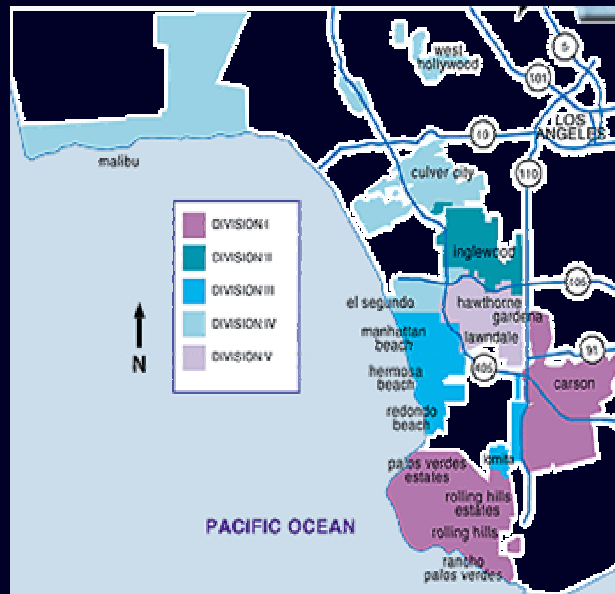
State-Wide Significance

One of the largest groundwater basins in Southern California, the Basin contains about 5,000,000 acre-feet of water and has an unused storage capacity of about 1,000,000 acre-feet.

Projected Imported Water Demands for the IEUA Service Area



West Basin and Central Basin Municipal Water Districts



Four Water Supply Sources Analyzed

- Imported Water
- Recycled Water
- Ground Water
- Desalinated Water

Central Basin MWD

<i>Source</i>	<i>kWh/af</i>
Imported Deliveries	2,544
Groundwater	
Natural recharge	350
Imported recharge	2,850
Recycled recharge	350
Recycled Water	
Los Coyotes	285
San Jose Creek	380

West Basin MWD

<i>Source</i>	<i>kWh/af</i>
Imported Deliveries	2,544
Groundwater	
Natural recharge	350
Imported recharge	2,850
Recycled recharge	350
Recycled Water	
Hyperion (gravity filters)	490
Hyperion (RO)	1,280
Desalinated Water	4,708

Climate Change and Global Warming



Council of the American Geophysical Union Statement

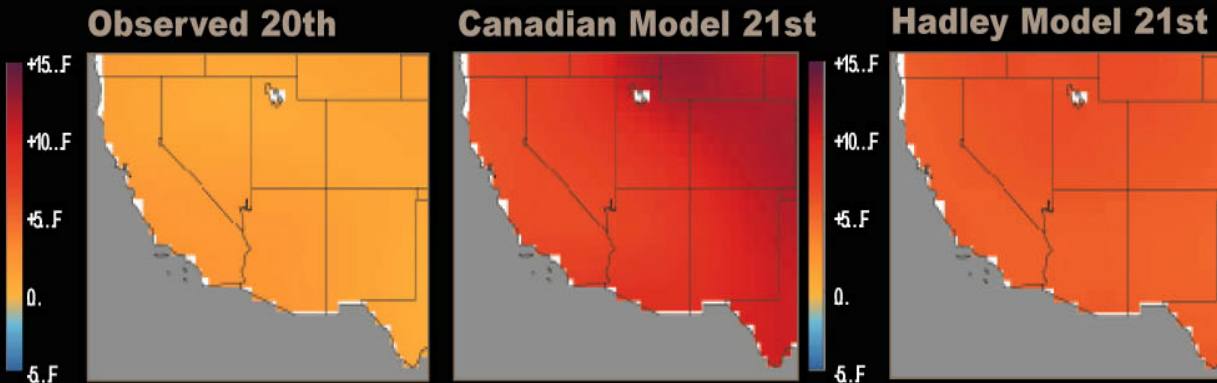
The rapidity and uneven geographic distribution of **these changes could be very disruptive.**

Council of the American Geophysical Union's position statement on climate change and greenhouse gases. January 28, 1999. AGU Release No. 99-03.

SW Temperature and Precipitation

Temperature Change - 20th & 21st Centuries

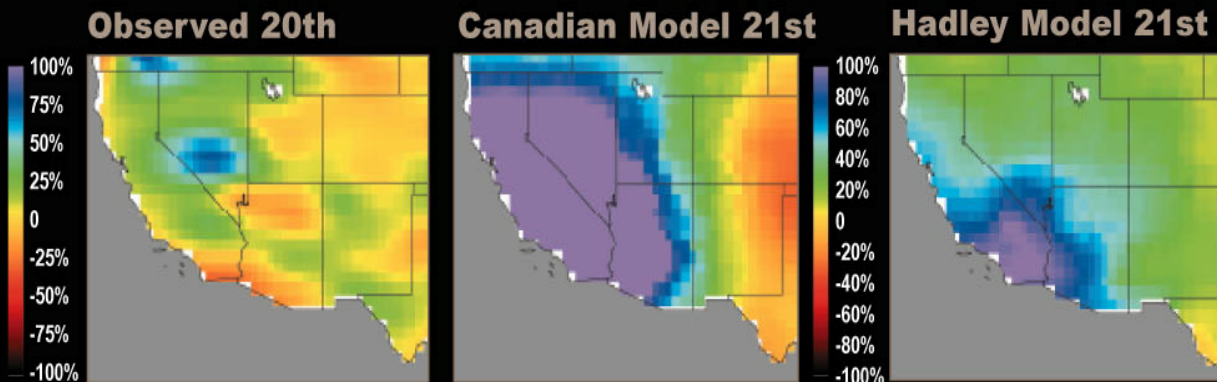
The west has warmed by about 2-5...F over the 20th century.



Temperatures in the West are projected to rise substantially in both models. The Canadian scenario projects increases of 8-11...F for Colorado, New Mexico, and Utah, while California is projected to warm by about 5...F by both models.

Precipitation Change - 20th & 21st Centuries

Much of the west has had increases of precipitation, but with some decreases in Arizona and the Central Rockies.



Both models project substantially increased rainfall, especially in California, Nevada, and Arizona.

Potential Climate Change Impacts on Water Resources

Acceleration of the hydrologic cycle and increased precipitation *on a global average* basis.

Increased ratio of rain to snow in mountainous regions, causing earlier runoff and reduced natural storage.

Increased evaporation and transpiration due to warmer temperatures.

Increased frequency of both droughts and floods due to increased variability.

Increased demand for water due to higher temperatures.

DIRECTIONS and CONCLUSIONS



Multiple Benefits Approach

With a focus on *multiple benefits*, we target various goals to be achieved through well-designed investments and policy strategies.

Integrated Management and Multiple Benefits

Integrated water management strategies and improved end-use efficiency can provide significant *multiple benefits*, including energy savings, improved environmental quality, and increased water supply reliability.

Additional Questions

What are the energy implications of different water strategies, and water implications of different energy strategies?

What are the multiple benefits of integrated water/energy (plus) policy strategies, and what values should be placed on the?

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Thoughts on the IEPR Opportunity

Define the boundaries of what is being integrated as inclusively as possible (e.g. energy, water, wastewater, air, impacts...)

Develop broad consensus that we have the rights parts in the right order, in the right pattern to develop a shared picture of the water/energy nexus.

A Role for Further Research

CEC's PIER program is immensely valuable as a means to facilitate critically needed policy-relevant research.

Focus on the important unknowns that will inform robust and cost-effective integrated policy strategies.

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